GUIDELINE FOR COMPUTING THE WATER USE EFFICIENCY [WUE] OF THE IRRIGATION PROJECTS

PERFORMANCE OVERVIEW & MANAGEMENT IMPROVEMENT ORGANISATION
CENTRAL WATER COMMISSION
MINISTRY OF WATER RESOURCES
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Irrigation Performance Overview [IPO] Dte.
Performance Overview & Management Improvement Organisation
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DEFINITIONS

Area Cropped	Actual Area sown under all crops in one irrigation year.
Area Irrigated	Actual area irrigated in a year - areas bearing two or more irrigated crops in a year are counted only once.
Available soil moisture	Available soil moisture is the amount of moisture which is held between field capacity and permanent wilting point of a plant in the soil.
Bulk Density	Bulk Density is the ratio of weight of oven dry soil to its bulk maximum volume.
Capacity Factor	Ratio of the mean supply level/capacity of a canal to the authorised full supply level/capacity.
CCA	The area on which crops can be grown satisfactorily. It excludes the un-culturable area from Gross Command Area.
Consumptive use(CU)	It is the quantity of water lost in evaporation, transpiration and that used by plants in metabolic activities from a particular area during a specified time. It is the crops water requirements during the crop period (season) while keeping the moisture in soil profile just to the field capacity level. It is expressed as depth of water in millimetres with respect to time.
Critical stage	Critical stage is the period during which yield of a crop is affected severely due to either inadequate or excess moisture.
Crop Ratio	Ratio of the areas under crops of two main seasons. Also known as Kharif/Rabi ratio.
Crop Season	Period of a year from the beginning of sowing to harvesting of crop including the period of pre sowing irrigation if any.
Delta	Depth of water that would result from a given water supply. Measured at the Canal Head/ Disty Head or at the outlet.
Drainage	Removal of excess water from the soil surface and/or from soil profile by artificial means to enhance crop production.
Drainage coefficient	The amount of water to be removed by drainage for optimum crop production. It is expressed in mm/day.
Duty	Number of hectare under a particular crop that can be brought to maturity by supply of 1 cumec of water flowing continuously for the base period.
Evapotranspiration (ET)	The total water lost due to evaporation from soil and transpiration from crop for a particular area during a specified time. It is generally expressed as depth of water in millimetres with respect to time. It is practically equal to Consumptive water use by a crop.
Field capacity	Field capacity is the moisture percentage of a soil on oven dry basis when the soil has been completely saturated and downward movement of excess water has practically ceased.

Gross command area(GCA)	The area of the command up to the farthest point in a command that can be supplied water. It includes un-culturable area, ponds, house, barren lands etc.
Intensity of irrigation	Ratio of the total irrigated area of each crop season to CCA in an irrigation year. Annual Irrigated Area = Intensity X CCA
Irrigation requirement	Irrigation requirement refers to the depth of water required to be applied for successful growth of crops, in a given time, exclusive of rainfall, ground water contribution and other natural resources. This, in other words, can be stated as net irrigation requirement plus other economically unavoidable losses.
Ultimate Irrigation Potential (UIP)	is defined as maximum area that can be provided with irrigation by most optimal utilisation of the available water resources duly accounting for the multiple cropping patterns; provided irrigation facility is fully developed.
Irrigation Potential Created (IPC)	is the Gross area that can be irrigated annually by the quantity of water that could be made available by all the connected and completed works up to the end of the water courses or the last point in the water delivery system. It is generally the Area that can be irrigated from a project in a design agriculture year that is, from the 1st July to 30th June next year for the projected cropping pattern and accepted water allowance on its full development. Theoretically it should match Gross Irrigated Area. *Irrigation Potential Utilized* (IPU) is the Total area for which water is actually delivered to the outlet up to 40 hectare blocks as planned.
Leaching requirement	is the fraction of the water entering the soil that must pass the root zone in order to prevent soil salinity from exceeding a specified value.
Potential Evapo-transpiration (PET)	is the amount of water evaporated in a unit time from a short uniform green crop growing actively and covering an extended surface and never short of water.
Two Seasonal Canal	Applies to a canal that supplies water during both crop seasons.
Water need or water requirement (WR)	Water need or water requirement (WR) is defined as the depth of water needed for raising a crop in a given period. It includes consumptive use and other economically unavoidable losses and that applied for special operations such as land preparation, transplanting, leaching etc.
Water shed	Water shed is the area above the given point on a stream that contributes water to the flow at that point. Catchment, basin or drainage basins are synonymous with it.

FOREWORD

National Water Mission under National Action Plan on Climate Change has been unveiled by Hon'ble Prime Minister of India on 30 June, 2008. Five goals have been identified under the National Water Mission. One of the five goals of National Water Mission is to increase water use efficiency in all sectors of water use by 20% by the year 2017 i.e. by the end of 12th Five Year Plan. The strategies have been identified in the Mission Document. It is more significant in irrigation sector, for about 80-85% of water consumption is in this sector. The prevailing water use efficiency of irrigation projects is in the range of 30 to 35% which could be enhanced to about 60% through systemic improvement. So it is the sector where there is immense scope for working upon improvement of irrigation efficiency & saving the huge volume of water for additional irrigation/other beneficial use.

Though conventionally, basin is a fundamental unit but WUE assessment for the entire basin can only be practicable by summing-up efficiencies of all the human interventions in the basin. In this vein, a project in a basin may be considered a focal unit of study.But to make-out a detailed diagnosis of completed major/medium irrigation projects catering to vast geographical area & workout a realistic/precise water use efficiency is a complex process which requires to be standardized. So, in 2004, CWC came out with a Handbook on Water Use Efficiency with sincere efforts of the then Director, IPO Mr. Anuj Kanwal & his team.

Based upon the feedback of some select WALMIs, the same has been modified now & made more crisp &precise. This Modified Guideline narrates the Standard Procedure for computing the Water Use Efficiency studies of the Irrigation Projects. It details about the information/data required to be collected, processed and analysed for assessment of the WUE of an Irrigation Project. It shall serve as a detailed diagnostic procedure/ready reckoner for the agencies deriving the water use efficiency of irrigation projects. It shall be helpful in identifying/pinpointing the specific problems with the project & in coming-out with detailed remedy/strategy for efficient use of water/enhancing the efficiency.

I appreciate the sincere efforts made by Shri Bhagat Singh, Chief Engineer, POMIO& his team in bringing out this Guideline. I also accredit to all, whose work has been referred in the compilation of this Guideline & extend thanks to practising engineers, scientist, authors and organizations in the field of improvement of Water Use Efficiency for Irrigation projects.

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New Delhi

INTRODUCTION: Water Use Efficiency can be defined in many different ways, by agriculturists, hydrologists and engineers. The value of a particular definition depends on the viewpoint of the author and the context of the hydrological boundary used, beneficial use, soil water storage and effective use of rainfall. Efficient on-farm irrigation depends on water use, energy use, labour and capital investment, and how these aspects relate to production and profitability, and there is no single definition that covers all these aspects of Water Use Efficiency.

CWC, vide the instant Guideline, carries forward the standardization of the definition of the **Water Use Efficiency (W_P)** which is broadly suggested by ICID into the following components:

- Reservoir filling Efficiency/ Diversion Efficiency/Operational Efficiency W_R
- Conveyance Efficiency W_C
- On Farm Application Efficiency W_F
- Drainage Efficiency WD

The overall efficiency of the project is taken as

$$W_P = W_R \times W_C \times W_F \times W_D$$

The reservoir efficiency is an important assessment of the efficiency of the design of the storage. It gives a clear picture of the changed hydrology regime, bad design in the hydrology assessments etc. The conveyance efficiency is a reflector of the losses in the conveyance systems. It indicates how well the system is designed and how well the system is managed. On Farm Application Efficiency (OFAE), is the most common understanding of the meaning of Water Use Efficiency, or Irrigation Efficiency for the agriculturists. In broad terms, OFAE is the percentage of water delivered to the field that is used by the crop& quite sensitive to application depths. Uneven/excessive depths, may be due to inflexible design or is poor management, adversely affects the distribution efficiency, is usually defined in terms of distribution uniformity. It is usually determined by measuring the depth of water and analysing the variation of water depths in the field. Since application efficiency is irrigation event specific & varies much, long-term data for 10 years is needed for assessment of its average trend, the last 4 years data may indicate its recent trend.

The practical achievable limits for components of WUE are as follows:

TABLE 1: ACHIEVABLE WUE LIMITS

Reservoir Efficiency		95%-98%
Conveyance Efficiency	Fully Lined System Partially Lined System Unlined System	70%-75% 65% 60%
On Farm Field Applications	Sprinkler/Drip Irrigation Basin/Furrow Irrigation	85% 65%
Drainage Efficiency		80%
IPU/IPC		85%

In addition to above, the Irrigation Potential Created (IPC) by a project and the actual potential utilized (IPU) is also an indicator of the optimum water use, overuse or underuse. A correlation of W_P with IPU/IPC is generally determined.

The scope of this Guideline is to crystallize the Methodology for computing water use efficiency &Irrigation Performance Analysis which involve identification of secondary & primary data, its collection- in particular the primary data for one agriculture year duration, processing and analysis of the data for the WUE exercise for irrigation projects.

Methodology for computing water use efficiency & Irrigation Performance Analysis: The purposes of Irrigation Performance Analysis is to diagnose operational problems - may be agronomic, system Engineering/Technical or institutional and suggest solutions and to identify potential changes in support of strategic planning, Irrigation Performance. The exercise is naturally useful for all stakeholders like Irrigation and drainage service providers and water managers, Government, lending and funding, research agencies, farmers and other service recipients.

To measure the Irrigation Performance over the field, actual results are compared with that planned/originally conceived. The Results are expressed as a dimensionless ratio in percentage. The factors instrumental for the deviation are analysed at length & corrective measures are detailed. As mentioned above, the overall efficiency is fragmented into four prominent components, worked out separately & multiplied to get the overall efficiency.
The water use efficiency of various components of the project shall be worked out for each crop season i.e. Kharif, Rabi & Hot weather/summer. The data requirement & arrangement for data collection may be detailed as per IPO-1 as under:

IPO-1 Data Requirement and Arrangement for Data Collection

SL No.	Details of Data Collection / Observation						
	Activity	Location	Period	Data			
				Secondary**		Primary*	Remarks
				Source	Duration		
1.	2.	3.	4.	5.	6.	7.	8.
1.	Reservoir filling Efficiency						
	Inflow Pattern						
2.	Canal/Conveyance Efficiency						
3.	On Farm Application Efficiency						
4.	Drainage Efficiency						
5.	Potential Created and Utilized						

***** Primary data is the data actually observed/measured first hand by standard data observation/measurement techniques using standard and properly calibrated instruments.

** Secondary data is the data obtained from agencies authorised and well qualified for collection of such data by standard data/observation/measurement techniques using standard and properly calibrated instruments.

Note:

Column on “Remarks” may be used for indicating status of secondary data actually collected / observed / proposed to be observed at identified sites by the consultant.

To start with, basic data, as per annexure-A, about the project are to be collected, and wherever applicable, be compared with current status.

Reservoir Efficiency: Reservoir Filling Efficiency may be considered as the ratio of maximum live storage attained in the reservoir in a particular year to the designed Live Storage of Reservoir. Data in this regard for each year of operation of reservoir shall be collected by the consultant as per IPO-2.
In case of diversion schemes, water planned to be diverted as per Detailed Project Report (DPR) shall be compared with the water actually diverted during the last 10 years on

monthly as well as on yearly basis. The reasons for difference between water planned to be diverted at project formulation stage and actual water diverted shall be analyzed and reasons for the same shall be identified. This could happen either due to non- availability of required quantum of water at diversion point in the river or due to development of any other project in upstream reach which might have affected the water availability at the downstream project. For the Weirs, the diversion efficiency may be computed as:

Ten year (10 daily) data are to be collected as per form no. IPO-2 & the Reservoir Efficiency may be presented as average.

IPO-2: Reservoir Storage Status

Gross Storage:
Live Storage:

Unit: MM³

							LOSSES			
Year	**Month**	**Storage (on the first day of the month)**	**Inflow during the month (Vi)**	**With-drawal (Vo)**	**Spill-over**	**Balance (2+3-4-5)**	**Eva-proration (Ve)**	**Seepage Losses (Approx) (Vs)**	**Net Storage (6-7-8)**	**W_R**
	1	2	3	4	5	6	7	8	9	10
YYYY1	June									
	July									
	August									
	September									
	October									
	November									
	December									
	January									
	February									
	March									
	April									
	May									
	Total									
YYYY2										

Conveyance Efficiency: The conveyance efficiency mainly depends on the length of the canals, the soil type or permeability of the canal banks and the condition of the canals. While in transit through canals losses like, evaporation, deep percolation, seepage, bund breaks, overtopping of the bunds, runoff in the drain, rat holes in the canal bunds etc. eventually happen. So it is necessary to assess the losses to determine the quantity of water actually delivered at the plant in the project area.

So the conveyance efficiency (W_C) = Water Delivery at inlet to the block of fields/Water released at the project head work

TABLE 2: CONVEYANCE EFFICIENCY

	Earthen canals			**Lined canals**
Soil type	**Sand**	**Loam**	**Clay**	
Canal length				
Long (> 2000m)	60%	70%	80%	95%
Medium (200-2000m)	70%	75%	85%	95%
Short (< 200m)	80%	85%	90%	95%
Note: Values applicable when level of maintenance is considered as very good				

Source: FAO Irrigation Management Training Manual 1989

To derive it, following approach may be followed:

Wherever control structures in the canal system are available at inlet and outlets, loss of water in such canals shall be worked out by having a water balance of complete canal. However, consultant shall be required to measure the canal discharges at inlet and outlets by velocity area method so as to validate the rating of control structures. Cross sectional area of the canal shall be measured by taking cross section at the location where discharge is proposed to be measured. Velocity shall be measured through properly calibrated and suitable type of current meters.

In canals where calibrated control structures are not available, the assessment of water loss in such canals shall be made by inflow and outflow method/Ponding loss method and estimating the conveyance loss factor and wetted perimeter of canals. Conveyance loss factor shall be evaluated in three reaches of canal i.e. head, middle and tail reaches. For correct assessment of overall efficiency for the whole length of the canal on the basis of evaluation of sample reaches, it is necessary that the canal portion (sample) selected in each reach for evaluation should be a representative one covering the general condition of that reach. For this, the lengths of canal sections which are heavily damaged/ cracked, moderately damaged, non-damaged, silted up etc. should be reflected in the sample reach in proportion to their respective length in that reach. At least 10% of the representative canal lengths in main, distributary, in minors, outlets are to be marked for the study. Based on conveyance loss factor and wetted perimeter of canal, the estimation of water loss in the whole canal shall be worked out corresponding to discharges in canal on various days of crop season and accordingly conveyance efficiency of the particular canal shall then be estimated.

The efficiencies of various main/branch canals and distributaries shall be worked out in accordance with one of the above two methodologies. The assessment of losses shall be made for lined and unlined canals separately.

For minors and sub-minors, assessment of losses may be made based on conveyance loss factor of the corresponding distributaries and wetted perimeter of the relevant minors and sub-minors. However, the losses so worked out shall be verified by inflow/outflow method for at least 10% of the minors and sub-minors.

Once conveyance efficiency of all canals, distributaries, minors and sub-minors have been estimated, the conveyance efficiency of the whole canal net work of project shall be worked out based on system approach.

Annual details of canal withdrawal may be collected in the IPO-3 format as under:

IPO-3: Canal Withdrawals in MM^3

Year	**During various seasons**			
	Kharif	Rabi	Hot	Total (Annual)
1	2	3	4	5

While observing conveyance loss by Inflow-Outflow Method: IS 9452 (Part-II) of 1980 or by Ponding Method IS 9452(Part-I) of 1993 (Reaffirmed 2004) may be followed.

Measure the conveyance efficiency for the complete agriculture year on average basis as per IPO-4.

IPO-4: Computation of the Conveyance Efficiency

Season/ Year	Canal	Discharge at Head in cumecs	Effective Length	Average Wetted Perimeter	Measured Losses							Actual delivery at the checkpoint	Observed Losses	Ratio of 11/12	Conveyance Efficiency
					Seepage Loss	Evaporatio n Loss	Accidentall Loss	Operational Loss	Other Losses (Describe)	Conveyance Loss Factor in cumecs/ Msq.m	Total Conveyance loss				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
YYYY/Rabi															
YYYY/Kharif															
YYYY/Other															
YYYY/Rabi															

A careful study of the data thus collected for the representative sections shall suggest in identifying the canal reaches needing improvements like lining, re-sectioning, stabilisation of embankments reach by reach, points of pilferages & in explaining all abnormal values. It shall be a material input for review the capacity of existing canals for present peak requirements & for extension of irrigated area. The structures like outlets-their functioning design, number, size, location, command area; cross regulators-their location, number as related with the FSL and discharge requirement; conversion of inlets into cross drainage works or drains; other miscellaneous structures such as bridges, escapes and water measuring devices shall be critically reviewed. It shall help in review/adequacy of O&M man-power/staff, portioning of sub-units & jurisdiction of Engineers. The exhaustive review would pin point the deficiencies in concrete and quantifiable terms & suggest appropriate remedial measures that can be undertaken.

Assessment of the performance of an outlet: The past ten years performance of the outlets of the representative command is to be studied from outlet register. Individual CCA allocations, area irrigated and intensity of irrigation are to be compared with that practically achieved. In case area irrigated on an outlet is much less than that proposed, the outlet location is to be re-fixed or outlet size may be reduced, besides reviewing the design criteria.

On Farm Application Efficiency [OFAE]
FOR SURFACE IRRIGATION SYSTEM

On farm application efficiency is an important and the most critical component of water use efficiency of project. It depends on the physical condition of field channels / water courses, whether these are lined or unlined, their length and type of strata through which these are laid. The method of application of irrigation water to individual farm plots/ field i.e. by flooding, furrow, drip, sprinkle etc is also an important parameter in determination of on farm application efficiency. On farm application efficiency may be worked out by the ratio of the crop water requirement as per Modified Penman Method for various crops for which irrigation is being provided by the project in each crop season i.e. Kharif, Rabi and hot weather to the quantum of water which is made available to crops from the field outlets of canal system.

The assessment of losses that takes place in field channels and water courses shall also be made by inflow/ outflow method on sample basis for lined and unlined channels separately. In case unlined field channels & water courses are passing through different soil strata, the assessment of losses shall be made for each soil strata separately. Primary objective of this exercise is to have a broad assessment of water losses which are taking place in field channels and water courses so that corrective measures, if required, could be evolved and implemented for increasing on farm application efficiency.

Accordingly, on farm application efficiency WF has two sub components:

1. WF1: Water courses/ field channels efficiency which account for the transit losses.
2. WF2: On Field Water application efficiency which account for the water loss from the field in deep percolation, leaching etc.

   WF = WF1 X WF2

To derive the on-farm application efficiency (W$_{F1)}$ following approach may be followed: Collect the areas under gravity, sprinkler or drip irrigation, water scarce areas in the command area. The representative 10% area from the command is selected including the area under Sprinkler or Drip Irrigation System, area which is water scarce etc. The OFAE (WF1) can be found as product of the weighted average (area under irrigation) for various efficiencies viz. for scarce areas, for area under sprinkler irrigation etc.

Conveyance efficiency (WF1) of the watercourse: The watercourse layout consists of a mainstream & branches aligned to serve the whole command area. The field channels/ watercourses are subject to intermittent wetting and drying unlike irrigation canals which run continuously. Hence the losses rates are much more in water-courses compared to canals which run continuously for long periods. These losses can be realistically assessed by inflow-outflow Method making discharge observations by Parshall flumes at all the delivery points (out flows) of the watercourse in the command area. The procedure of observations is as given below:

- Install one parshall flume permanently (for observation period) near the outlet head of watercourse to assess the discharge coming out of the outlet during whole of the observation period.

Å Install parshall flume at each of the turnout (nakka) and observe the discharge delivered to each holding during its turn. Observe distance between turn out to turn-out (or from one flume to next flume) and account for the filling time of watercourse and similarly observe the emptying time of the watercourse.

Å With the water delivered at each turn out (nakka point) record the irrigation done by the concerned farmer.

Å Calculate percentage of water received at each holding turn-out (nakka point) to water delivered at outlet head during the same time period.

Å Assess the overall position of losses, and draw intensity plan. In this intensity plan the ranges of percentages of water received by various shareholders are presented in different colours e.g. the shareholders getting water (i) more than 90% or between (ii) 80-90% (iii) 70-80% (iv) 60-70% (v) 50-60% and below 50% of water released at the head during the same turn period are depicted in different colours. This colour picture would indicate the pattern of losses.

Å Plot an hourly discharge curve showing the discharge passed through outlet each hour during the observation period. This is required to account for variation in discharge if any.

Å Draw curves showing the performance of main watercourse in which (i) discharge released at outlet head is plotted along with corresponding discharges received at turn-outs (nakka points) and (ii) percentage of water received at turn-outs are plotted against the distances at which the flumes are fitted on main watercourse. This would indicate the pattern of losses in a continuous reach.

Å Calculate the overall percentage of water delivered at turn-outs (nakka points). This would give the conveyance efficiency (WF1) of the watercourse.

Å Assess reasons for losses. A sample data collection shall be as per IPO-5.

IPO-5: Measurement of Losses in a Watercourse by Inflow-Outflow Method covering whole Command Area of the Watercourse

1.Name of the Watercourse taken up for observation				
2.Authorised discharge of outlet				
3. Details of Warabandi/Rotational Turn Schedule				
<u>Sub Group</u> Holding No	Area in ha	Time Schedule from to	Total time allotted hrs mats	Additional filling time/emptying time hrs mats
4. Discharge observations at various flumes				
(i)Flume No. (Say F-1)				
(a)Location of flume				
(b)Distance from Head flume				
(c)Land holding /Sub group No.				
(d)Area of holding				
(e)Duration of turn and time				
(f)Discharge observation				
S.No.	Time hrs	<u>Reading of flume</u> u/s d/s	Discharge as observed from standard tables	Remarks
Average discharge =				
(g)Volume of water passed through the flume: Duration of turn X Average discharge				
(h)Area Irrigation:				
S.No.	Name of crop		Area irrigated	
			Total	
5. Percentage of water delivered				

S.No.	Flume No.	Distance from the head Flume	Actual quantity of water recd. at outlet head during turn	Actual quantity of water passed through the turnout during turn	Percentage of water received at the turnout	Remarks
Total of whole of the turn schedule:						
6. Total quantity of water received at the out let head						
During the complete rotational turn :						
7. Total quantity of water delivered to farmers :						
8. Overall percentage of water received or Efficiency of watercourse						

Measurement of Losses in Branch Watercourses by Ponding Method: To evaluate the performance of each of the branch watercourse, it would be necessary to link the rate of loss with its total running period each time water enters a new branch watercourse. To do this, it would be necessary to draw a typical *infiltration curve* for the watercourse. This is drawn by observing seepage losses by the ponding method. From this curve, we can find the infiltration stage co-efficient, which may be defined as the ratio of average loss per hour during the running period in the new branch watercourse to the overall loss per hour during running for total rotational period of 168 (7x24) hours. This co-efficient would be used for accounting for the initial losses in new branch watercourses.

The absorption loss in a watercourse is a function of (i) time for which each portion of branch runs, (ii) length of running portion and (iii) infiltration stage co-efficient. The comparative assessment of the loss in each portion of run (turn-out to turn out), can thus be made by multiplying these factors. The overall performance of the various branches of water course can thus be evaluated.

In a branch watercourse AB, N1, N2 é é é . N6 are the turn-outs (Nakka points) located at distances from turnout to turnout as d1, d2 é é ..d6 and each draws water for t1, t2, .t6 hours. Let the infiltration stage co-efficient for running in new lengths (from turnout to turnout) be C1, C2é é é é ., C6. The turnout draws water turn by turn starting with N1. Thus time for which water runs in the new length (from turnout to turnout) is equal to the total time of all the turn-outs on lower side of the corresponding turn-out e.g. water in length d1 would run for the period T1= t1+t2+t3+t4+t5+t6, similarly time periods for various lengths are as given below :

For d2,T2=t2+t3+t4+t5+t6

For d3 ,T3=t3+t4+t5+t6

For d4 ,T4=t4+t5+t6

and so on.

The *absorption loss* in various reaches would thus depend upon their cumulative values of products of metre, hours & co-efficient i.e. d X T X C. Maximum coverage of these meter-hours-coefficient under minimum lined length would indicate the efficient economical design.

The absorption loss can be computed by taking 10% representative sample of the water course in the command area. The water course ID is given and the sample is averaged weighted arithmetically. The assessment by ponding method does not take into account the operational losses, accidental losses, and other losses due to lack in maintenance of these channels.

Assessment of the On Field water Application Efficiency in the Farm in water scarce areas (WF1): The amount of water required for irrigation may be approximated by sampling the soil at several places in the field and estimating the moisture deficiency or the depth of water required to bring the soil in the root zone to field capacity. The water application is then figured out on the basis of prevalent application efficiency.

Before irrigating the area under consideration, find out the depth of available soil moisture upto the root zone at head, middle and lower reaches. From the data of water course and duration of time for which water has been applied, work out the average depth of water applied to the field. Find out the depth of moisture in the soil at its field capacity in the area under consideration. The depth of water available in any soil depth i.e. cm. of water per cm. of soil or cm. of water per meter of soil is given by the following equation:

D : ɔs x d x ɤ
ɔw x 100

Where,

D : cm. of water in soil depth (d)

d : depth of soil in cm.

ɔs: bulk density of soil : Weight of oven dry soil in gm. / field volume of sample in cubic cm.

ɤ : moisture content of soil in % by weight

ɔw : density of water taken as 1.

For sampling, two locations should be selected near the side of the field where irrigation is to be started and two locations at the opposite end of the field. Measurements should also be made at other locations as indicated by any critical conditions in the soil, such as an area that dries out first or stays wet longest. The sampling depth should be in increments of 30cm and extended upto root zones. The soil samples as taken are weighed, dried in an oven, and then weighed again. The dry bulk density and moisture content are calculated. The depth of water available in the sampled soil depth is then calculated by using the formula given above.

Work out the moisture deficiency of moisture in the soil as per IPO-6. The moisture deficiency is then compared to the depth of water at field capacity. The ratio will give the application efficiency.

Knowing the amount of water applied and the water deficiency in the soil, the field application efficiency is calculated.

IPO-6 OFAE (WF1) in water Scarce Areas

Location of irrigation field						
Field	Length		Width		Area	
Depth of soil moisture as available before irrigation						
Reach (Head, middle, tail)	Depth of soil sample cm	Moisture content %	Dry bulk density	Water depth % Col.3 xCol.4	Water depth in cm. Col. 5x30 100	Mean water depth cm
1	2	3	4	5	6	7
Discharge observations of water entering the field by (parshall flume):						
S.No.	Time	Readings of flume U/S D/S	Discharge as observed from standard tables	Remarks		
Flow measurements:						
Average discharge:						
Duration of flow						
Volume of water passed through the flume : (b) X (c)						
Depth of water application: Vol. of water applied (d)/Area of field						
Depth of soil moisture at field capacity						
Reach (Head, middle, tail)	Depth of soil sample cm	Moisture content %	Dry bulk density	Water depth % Col.3 xCol.4	Water depth in cm. Col. 5x30 100	Mean water depth cm
Soil Moisture deficiency						
Reach (Head, middle, tail)	Soil Depth in cm	Average depth of moisture as available in the soil sample of 30 cm each	Moisture deficiency (6)-Col.3			
Field application efficiency : Moisture deficiency x 100 Depth of water application						

Assessment of the On Farm Application Efficiency for sprinkler & Drip Irrigation System (W_{F1}): Collect data for 10% of the representative area under Sprinkler or drip irrigation system in the Command area. Collect the basic data of the field like field location, dimension, and topography, Soil Characteristics, irrigated crop details-crop cycle, root development, irrigation System, Irrigation Management-usual time period, wind Characteristics during the test etc.

Instruments required for the field are - Pressure gauges with pitot arrangement, Stopwatch, flexible hose with diameter greater that the outside diameter of sprinkler nozzle, catch containers (upto 100 in nos.) to cover the entire field, graduated cylinder for measuring the water in each can, large capacity container with markings, tools for soil moisture evaluation-drill (gravimetric), tensiometer etc.

Apply the Performance tests- Measure operating Pressure at different locations**,** Measure Flow rate, Measure Water Depth in the catch cans (vertical for Sprinkler, Horizontal for Drip). The Catch can Test should be done as follows:

Å The containers are to be placed at strategic locations in the field. Take care of the windy or vegetation affecting the catch.

Å A separate can is to be put outside the field to approximately check the evaporation, influence of clouds, wind, humidity etc. The water depth evaporated should be deducted from the water depth in each container.

Å Duration of the test need to be normal irrigation time in order to take care for wind and evaporation effects.

Å Abnormally low or high catch should be indicated separately. Collect data as per IPO-7 & IPO-8.

Å Compute WF1

IPO-7: Data analysis for Sprinkler Irrigation

Farm ID	CU	Standard Deviation	DU	Standard Deviation

IPO-8: Data analysis for Drip Irrigation

Farm ID	EU	Standard Deviation	CV	Standard Deviation

About the terms used above:

A) DISTRIBUTION UNIFORMITY (DU): It is an expression that describes the evenness of water application to a crop over a specified area, usually a field, a block or an irrigation Project. It applies to all irrigation methods as all irrigation systems incur some non-uniformity. It is usually determined by measuring the depth of water falling into a grid of catch cans during an irrigation event and analysing the variation of water depths in the catch cans.

It is defined as: *DU = Average lowest 25% of measurements/ Global average*

A good number of sprinklers or emitters must be measured and recorded. Two averages are calculated from these records: the average of all the measurements, known as the global average, and the average of the lowest 25% of measurements, also known as the low-quarter average. Ratio of two is DU. The lower the value of DU, the poorer the uniformity of application and the lower the Distribution efficiency. The run time to reach the driest part of the farm field is to be corrected as

Corrected Run Time = Run Time/ DU

B) COEFFICIENT OF UNIFORMITY (CU): It is commonly used for evaluating the equal distribution of water in the field. The over irrigation or under irrigation area can also be assessed. The coefficient CU for sprinkler systems is often evaluated using a grid of catch cans. For Sprinkler system, it is defined as:

CU = 100 [1 ï (sum |X-x|)]/ sum X

Where: X is depth of water in individual catch cans *& x is* average depth of water in all catch cans.

FOR DRIP IRRIGATION SYSTEM: In trickle irrigation, distribution efficiency is a measure of the variation of emitter flows down a lateral or throughout an irrigation block. Measurement of applied depths in trickle irrigation is more difficult, so distribution efficiency is usually specified in terms of Emission Uniformity (EU) & Coefficient of flow Variation (CV).

EMISSION UNIFORMITY (EU): EU is another name of CU of the sprinkler irrigation which is defined as follows:

EU = 100 (1 - 1.27 CV) ×Q min /Qave

Where: CV is coefficient of manufacturing variation for the emitters; Qmin is minimum emitter flow in block (l/h); Qave is average emitter flow in block (l/h).

For trickle systems, the volume of water discharged in a specified interval of time at several emission device locations is used. The uniformity values are more in Drip Irrigation than in Sprinkler Irrigation irrespective of the fact that water redistributes itself after irrigation in the soil. The redistribution factor is not present in Drip Irrigation.

COEFFICIENT OF FLOW VARIATION (CV): CV integrates emitter discharge fluctuation along a lateral for a given operating pressure. Lower the CV, more uniform the emitters discharge.

CV = ã [(Qx-Qav)^2 /n-1]/Qav; where Qx is Discharge of each emitter under analysis (l/h); Qav is Average discharge of the emitters (l/h); n is discharge points usually 50 operating at reference pressure.

CV value given by the manufacturer can also be used to measure the discharge of new emitters.

On Farm Application efficiency can be estimated from the distribution uniformity (DU) of the applied water after developing an empirical relationship for considering other factors such as drainage, evaporation and application rate in mind. Using pairs of lysimeters, OFAE under different types of Sprinkler system/ Drip System may be found out. A correlation of DU or EU then can be framed. In practical terms DU for sprinkler system and EU for Drip system in % terms may be taken as OFAE (WF1).

Assessment of the On Field water Application Efficiency in the Farm (WF2)

Take representative sample area, Collect data for last 10 years and co-relate with the actual observations, Assess actual cropping pattern and coverage, weighted average rainfall in the command, the reference evapo-transpiration in the area, the Crop co-efficient in respect of various crops, the Effective rainfall in the command & the Percolation losses in fields. Calculate the consumptive use of water for each fortnight (7 or 10 days interval can also be taken) by Modified Penman equation (FAO-24) using climatological data such as temperature, relative humidity, evaporation, wind velocity, sunshine hours and crops factors etc, for one ha. of each crop separately. Calculate the field irrigation requirements for each fortnight using data on percolation losses, special requirements for nursery preparation and effective rainfall etc. for one ha of each crop separately. Knowing the field irrigation requirements for each data on percolation losses, special requirements for nursery preparation and effective rainfall etc. for one ha of each crop separately. Knowing the field irrigation requirements for each crop, work out water requirements of each fortnight for one hectare of composite cropped area as per the existing pattern. Since the sowing dates of various seed varieties of a crop are spread over a period ranging from 15 to 30 days or so (depending upon their duration), it is imperative to take due cognisance of this aspect and detail the water requirements of various crops, separately as per the sowing dates of their seed varieties and practices followed in the field. Knowing water requirements per hectare in each fortnight, workout the discharge required at outlet head to cover entire CCA of outlet and the corresponding discharge and running period of the distributary. Compare these requirements with the actual releases being made from the system and examine the WF2.

IPO-9 Actual Cropping Pattern

Culturable Command Area (in ha):

Sl. No.	Crops	Area (in ha)	Percentage (w.r.t. total area)	Base Period of crop
1	2	3	4	5

IPO-10 Weighted Average Rainfall in the Command of the Project

Year	Month												Total
	June	July	August	September	October	November	December	January	February	March	April	May	
1	2	3	4	5	6	7	8	9	10	11	12	13	14

IPO-11 Computation of W_{F2} by measuring Irrigation Water Requirement by modified Penman method

Name of crop	Crop period	ETo (mm)	Kc	ET crop (mm)	P (mm)	Re (mm)	NIR (mm)	FIR (mm) Use actual On Farm Application loss figures	Actual Supply	Ratio 9/10 W_{F2}
1	2	3	4	5	6	7	8	9	10	11

EToï Reference Evapotranspiration
Kc-Crop-co-efficient
ET crop -Crop-Evapotranspiration (This is ETo X Kc)
Re -Effective rainfall
P -Percolation Loss, Use Actual Field data as per standard methods.
NIR ï Net Irrigation Requirement = (Et+P ï Re)
FIR -Field Irrigation Requirement = (NIR/ W_{F1})

Drainage Efficiency: Drainage efficiency is a measure of the amount of water draining from the root zone actually collected and discharged by the drains. The drainage Efficiency is computed as

$$WD = Wd / (Ws+Re-CU)$$

Wd is total water drained from the system; Ws is total water supplied to the system; Re is effective rainfall during the period under consideration; CU is water used by crops to meet evapotranspiration needs.

WD has an important concern for Reuse of Water or d/s use of water**.**

The parameters like Water table fluctuations, seasonal or long term; Drain Effluent quality; Drainage requirements of the area; Water logging and soil salinity changes are also the essential components to be thoroughly studied under the Drainage Efficiency.

This may be derived as under:

Identify representative 10% command area plots and mark on the map; evaluate the Total amount of water released to various fields in the command area; evaluate the Amount of water required by various crops; evaluate the Amount of water drained out from the command area after fulfilling need of various crops; evaluate the Drainage Efficiency as per IPO-12.

Also identify Location of groundwater pumps and discharge points, observation wells; identify Collection and reuse of surface drainage as part of any surface drainage system; photograph the areas under sever deterioration; collect the following maps of the representative areas and correlate the areas in the command needing special attention:

Soils Characteristics Maps: Indicating the Electrical Conductivity (Ec), Soil pH etc. may be collected.

Groundwater Characteristics Maps: Indicating the Peizometric head locations, Aquifer Characteristics (Thickness, Hydraulic Conductivity, Transmissivity, and Specific Capacity etc.), GW quality parameters like Ec, SAR may be collected.

IPO-12: Data required for working out Drainage Efficiency on the representative Command Area Plots

Year	Amount of water released from dam/weir in Mm^3	Amount of water Utilized by all crops (CET) in Mm^3	Amount of water drained out of command in Mm^3	Depth of G.W. Level in the command	Change in ground water level in the command	Drainage Efficiency 4/(2-3)
	2	3	4	5	6	7

Irrigation Potential Created and Utilised: An assessment of irrigation potential created and utilized based on secondary data collected from the state Government is to be made and compared the same with irrigation potential as planned at project formulation stage. The reason for any gap between irrigation potential created and utilized is to be identified, analyzed and remedial measures be recommended for bridging this gap so that the objectives of project as envisaged at project formulation stage could be achieved. This assessment shall include the following two aspects:

There could be differences in the irrigation potential planned to be created at project formulation stage and actually created. The reasons for this gap have to be identified, analyzed and measures recommended for bridging this gap.

There could also be difference between the irrigation potential actually created and utilized. The reasons for this gap shall also be identified, analyzed and measures recommended for bridging this gap.The data regarding the IPC and IPU is compiled as per IPO-13. The area under Minor Irrigation is to be computed separately.

IPO-13: Assessment of the IPC & IPU

	Potential creation				Potential utilization				% age utilization
Year	Kharif	Rabi	Summer	Total	Kharif	Rabi	Summer	Total	
1	2	3	4	5	6	7	8	9	10

Various Issues like present area under cultivation of different crops, their yield, water requirements and approximate cost of cultivation; the irrigation Potential that has never been utilised; the irrigation potential that has not been utilised regularly; the irrigation potential that has been abandoned are also to be studied. The reasons for the above are to be deduced- which may include: Changed Cropping Pattern than DPR; less Rainfall; poor Dependability Criteria; diversion for Non irrigation Purposes; poor Maintenance Issues; less Inflow received from the reservoir; change in Command Boundary; unauthorised Uses & other Reasons such as administrative, management, technology etc. The suitable corrective measures may be suggested.

Status of PIM and WUA in the Command Area; the extent of pro-activism of the Associations & the roles being actually discharged on ground needs to be looked into & reported. State level legislations for canal operation, water charges etc. are also to be studied & commented upon.

Assessment of the Changes in the Cropping Pattern: Since commencement of an irrigation project, socio-economic status of farmers gradually up-lifts which shifts the psyche of the farmers from survival irrigation i.e. adequate grain or cereal for family and fodder for the cattle to commercial irrigation coupled with other factors like better seeds, fertilizers, storage &marketing /other infrastructural facilities.

For assessment of changes in cropping pattern, last 10-15 years data as per IPO-14 may be collected & on comparing the projected crops with those actually grown in the command area future trends can be vividly seen.

IPO-14: Assessment of the Cropping Pattern

Year	**Season**	**Actual Cropping Pattern**			**Actual CU**
		Crop1/ Delta	Crop2/ Delta	Crop 3/ Delta	

FORMAT FOR THE REPORT ON WATER USE EFFICIENCY: Executive Summary of the Report may be given in the beginning of the report highlighting the details as given in Annex-B.

Contents (Chapter 1 to 8 as given below)

1. A Project Details
    - 1.1. Introduction ï including objective of the studies
    - 1.2. Project ï Salient features
    - 1.3. Index Map

1. B Project Infrastructure and Canal Net Work

2. Dam/Reservoir Efficiencies
    - 2.1Hydrology
        - 2.1.1 75% annual dependable flows (designed/ anticipated)
        - 2.1.2 Actual 75% dependable annual flows
        - 2.1.3 Inflow pattern on ten daily / monthly basis
        - 2.1.4 Water spillage
    - 2.2 Evaporation losses in the reservoir
    - 2.3 Seepage losses from the reservoir
    - 2.4 Calculation and presentation of Efficiencies in tabular form

3. Canal/Conveyance Efficiencies
    - 3.1 Seepage in various reaches of various canals
    - 3.2 Evaporation losses in various canals
    - 3.3 Calculation and presentation of Efficiencies in tabular form

4 On Farm Application Efficiency
    - 4.1 Cropping pattern
        - 4.1.1 Designed cropping pattern
        - 4.1.2 Actual cropping pattern
        - 4.1.3 Comparison
    - 4.2 Weighted average rainfall in the command of the project
    - 4.3 Reference evapotranspiration in the area under study
    - 4.4 Crop co-efficient in respect of various crops
    - 4.5 Effective rainfall in the command
    - 4.6 Percolation losses in paddy fields
    - 4.7 Gross irrigation requirement
    - 4.8 Field irrigation requirement
    - 4.9 Net irrigation requirement
    - 4.10 Calculation and presentation of Efficiencies in tabular form

5 Drainage Efficiency
    - 5.1 Total amount of water released to various fields
    - 5.2 Amount of water required by various crops
    - 5.3 Amount of water drained out from the command area
    - 5.4 Adequacy and performance of existing drainage system
    - 5.5 Need for external drainage system, if any
    - 5.6 Problems of water logging, salinity, alkalinity, if any
    - 5.7 Calculation and presentation of Efficiencies in tabular form

6 Potential created and Utilised
    - 6.1 Yearwise Potential Creation
    - 6.2 Yearwise Potential Utilization
    - 6.3 Reasons for the gap & recommendation for bridging the gap.

7 Conjuctive use of ground & surface water.

8 Findings and Recommendations*

8.1 Recommendation for improvement in Water Use Efficiency

8.1.1 Dam/ Reservoir Efficiency

8.1.2 Canal/ Conveyance Efficiency

8.1.3 On Farm Application Efficiency

8.1.4 Drainage Efficiency

DATA VOLUME

Part-A	Reservoir Storage Status in IPO-2 for different years since commission
Part-B	Canal Withdrawals in IPO-3 for different years since commission
Part-C	Actual Cropping Pattern in IPO-9 since beginning of irrigation
Part-D	Weighted Average Rainfall in the Command of the Project in IPO-10
Part-E	Irrigation Water Requirement by modified Penman method in IPO-11
Part-F	Year wise Potential created and utilized in IPO-13
Part-G	Data required for working out drainage efficiency in IPO-12

PLATES

- Index Map
- Irrigation Map (showing control structures)
- Drainage Map
- Photographs of important components of Irrigation System
- Photographs of damaged system components
- Photographs of waterlogged, saline and alkaline areas

*The findings shall specifically cover the following:

Identification of canal reaches with their lengths which have become damaged and need for repair/ restoration to original section / lining etc.

Identification of structures that need repair or replacement.

Length of canals with bank failure that needs repair.

Any other structural/non-structural measures required.

The findings in regard to reservoir filling efficiency, irrigation potential created & utilized and drainage efficiency are to be elaborated. The recommendations for improving the over-all performance of project to the level envisaged at project formulation stage shall also be made.

Annexure-A

SYSTEM DESCRIPTION

Code	Descriptor	DPR status to be compared with present status wherever applicable
A. Basic Information		
1.	Name of the Irrigation Project	
2.	Latitude/ Longitude	
3.	State/Districts Benefited	
	Basin map, River, Catchment, Canal Systems, Command details - Preferably on GIS platform using basin/rivers data form WRIS	
4.	Any studies done on the project earlier	
B. Institutional		
1.	Year Construction started	
2.	Year first operational/ Commissioned	
3.	Details of management & various respective agency functions- Government, Private, Joint, -details of agencies involved with respective roles, Water Users Associations	
4.	Annual Revenue collection form irrigation & non-irrigation uses & respective unit rate lists.	
5.	Land ownership-Government, Private	
C. Administrative Information		
1.	Details of extent Legislative / Statutory measures in force for Irrigation Sector & applicable to the project under study	
2.	Field staff set-up for Reservoir operation, Canal & conveyance system Maintenance & Repairs, Farmers grievances, Measuring flows, Raising water charges etc for the project & extent of its adequacy	
3.	Realisation of water charges and methods prescribed for it	
4.	Project level inter-departmental co-ordination committees constituted or not. If yes, who co-ordinates, how often they met and their effectiveness	
5.	Other methods of interaction & co-ordination with water users, if any	
D. Projected Benefits at DPR stage		
1.	DPR projection of the Benefits, B/C ratio projected	
2.	Appraisal Papers	
E. Climate and soils		
1.	Climate like Arid, Semi-arid,Humid, Humid tropics	
2.	Average annual rainfall (mm)	
3.	Average annual reference crop potential evapotranspiration, Et_c(mm)	
4.	Peak daily reference crop potential evapotranspiration, Et_c(mm/day)	

5.	Predominant soil type(s) like Clay, Clay loam, loam,Silty clay, loam Sand etc.; percentage of total area of each type & respective average depths.	

F. Water source and availability		
1.	Water source - Storage on river, Groundwater, Run-of-the river, Conjunctive use of surface and groundwater	
2.	Water availability ï Abundant, Sufficient, Water scarcity	
3.	Number and duration (months) of irrigation season(s)	

G. Reservoir		
1.	Reservoir Area	
2.	Catchment Area	
3.	Reservoir levels & capacities as designed vs. actual	
4.	Rules curve (Target Level) for filling and depletion of Reservoir	
5.	Comparison with assumed/ designed inflows at the project & reasons for variation	
6.	Envisaged v/s actual uses like Drinking, Irrigation, Power Generation, Industrial, Navigation, Ecological purposes, Others (if any)	
7.	Comparison of releases for Irrigation with the actual demand (season-wise)	
8.	Reservoir Sedimentation	
	ÅAssumed ï area Capacity	
	ÅActual Area ï Capacity	
	ÅLoss in capacity & likely effects	
	ÅLast sedimentation study	
	Live storage conceived vs. actual	
9.	Reservoir Operation, release & Regulation method (Season to season)	
	Evaporation, seepage losses	
10.	Measures for control of water losses due to seepage, leakage and evaporation	

H. Headworks		
1.	Latitude & Longitude	
2.	Type of headworks with structural details ï Dam, Barrage, Weir	
3.	Year of completion & construction cost	
4.	Operation system for water release, their sufficiency and efficiency	
5.	Special problems, if any	

I. Conveyance system		
1.	Name of the Main Canal / Distributaries' / Minor	
2.	Whether Canal Operation at the release structure is Automatic, Manual	
3.	Total length of canal / distributary/ minor (km) ï lined & unlined	

4.	In each uniform length of section, comparison of designed canal parameters like c/s, wetted perimeter, FSL, free board at each uniform cross section	
5.	Unauthorised withdrawals & measures to check such withdrawals	
6.	Drainage problems on account of losses, including the extent of areas affected by water logging during the last 4-5 years.	
7.	Details of transit withdrawals for other population benefited, if any	
8.	Total number of canal outlets, its individual capacity, frequency of release, area under each outlet-designed & actual; in the whole distribution network.	
9.	General condition of the canal / distributary / minor and other control structures enroute (specify chainages and the length affected): Breaches or cracks, Siltation ï specify length affected and depth of siltation, Bathing / washing points, Deterioration of canal shape(specify chainages), General soil condition and stability of banks	
J. Infrastructure – Irrigation		
1.	Method of water abstraction, i.e. Pumped diversion, Gravity diversion, Groundwater	
2.	Water delivery infrastructure (length and %) i.e. Open channel, Lined, Unlined, Pipelines	
3.	**Type** - i.e. None, Fixed proportional division, Gated -manual operation, Gated -automatic local control, Gated ï automatic central control **AND location** i.e. Control structure at main intake only; Control structures at primary and secondary level; Control structures at primary, secondary and tertiary level - **of water control equipments**	
4.	Discharge measurement facilities Å **Location** i.e. None, Primary canal level, Secondary canal level, Tertiary canal level, Field level Å and **type** Flow meter, Fixed weir or flume, Calibrated sections, Calibrated gates etc.	

K. Infrastructure – Drainage		
1.	Area serviced by surface drains (ha)	
2.	Type of surface drain - Constructed /Natural	
3.	Length of surface drain (km) ï Natural, Constructed, Open, Closed	
4.	Area serviced by sub-surface drainage (ha)	
5.	Number of groundwater level measurement sites	

L. Water allocation and distribution		
1.	Type of water distribution - On-demand/ Arranged-demand/ Supply orientated	
2.	Frequency of irrigation scheduling at main canal level ï Daily, weekly, Twice monthly, Monthly, Seasonally, None	

3.	Predominant on-farm irrigation practice - Surface ï furrow, basin, border, flood, furrow-in; basin; Overhead ï rain gun, lateral move, centre pivot Drip/trickle; Sub-surface	

M. Command Size		
1.	Commanded (irrigation) area (ha)- Originally conceived vs. actual	
2.	Total number of water users supplied	
3.	Average farm size (ha)	
4.	Average annual irrigated area (ha)	
5.	Average annual cropping intensity (%)	

N. Cropping		
1.	Main crops each season with percentages of total command area	

O. Socio-economic		
1	Farming system- Cash crop; Subsistence cropping; Mixed cash/subsistence	
P. Irrigation Potential		
1.	Culturable Command Area- Already developed/ Yet to be developed/Planned irrigation potential/ Gross Irrigated Area	

Q. Operation & Maintenance		
4.	Detailed analysis of staff employed in O&M & its adequacy	
5.	Actual annual requirement of funds for O&M against made available in past 5 years-deficiency if any, with annual expenditure incurred	
6.	Physical condition of different components of the irrigation systems	

R. Communication Level		
1.	Detailed study on effectiveness of the communication system- including the modes, with the farmers & its impact on project performance	
2.	Whether the existing communication system is adequate or does it require any improvement	
3.	Condition & types of project roads & lengths maintained by the department	

S. WUA/PIM		
1.	Total number of water usersô Association/ Committees & the number of associations actually active on ground & their extent of involvement	
2.	The conveyance system with the Irrigation of each association/ committee	
3.	Whether any built-in mechanism exists to see that the farmerôs organisations become viable and sustainable and further to ensure that they do not become centres of vested interest?	

Annex-B

Summary of Water Use Efficiencies

1 Name of the Project

2 River/ Basin

3 Type of Project ï Major/ Medium

4 Type of Structure - Dam/ Barrage/ Weir

5 Location ï Latitude/ Longitude/Town/ District/ State

6 Length/ period of data used for study

7 Culturable command area (CCA)

8 Ultimate irrigation potential (UIP)

9 Potential created (PC)

10 Potential utilized (PU)

11 Main recommendations for overall improvement of the project

12 Name of the consultant/ agency who carried out study

13 Storage efficiency

(a) Reservoir filling efficiency

(b) Inflow Patterns

14 Conveyance Efficiency

(a) Main canals

(b) Branch canals

(c) Distributaries

(d) Minors

15 Field Application Efficiencies for all major crops

16 Drainage efficiency

Data base shall include all details collected during study such as cropping pattern (planned/ actual) withdrawals, irrigation water requirement for each crop etc.

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